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LIMITED CIRCULATION

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AGRICULTURAL MEMORANDUM No. 1027

AGRICULTURAL LAND CLASSIFICATION - Comparison of Two Methods for Mapping Temperature

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Summary

The author has produced a map of the median accumulated temperature - January to June, above base 0°C, for the 20-year period 1961 to 1980. Some of the differences between this map and one produced by Soil Survey of England and Wales using data supplied by the Meteorological Office are analysed. The main differences are due to many more stations used by the author, albeit with less than a complete 20-year record, and to the superior, but less computer compatible, mapping technique used by the author. The differences are most noticeable in all the lowland areas but only one area Central Southern England, is presented for comparison.

1. Introduction

In the revised Agricultural Land Classification Scheme accumulated temperature January to June will be used in place of growing season for representing the geographical variation of beneficial receipts of heat energy. The main criteria for accurate mapping of accumulated temperature for any period of months are:-

a. Plentiful good quality data.

b. Using the accurately mapped topographic field to best advantage.

c. Allow for the strong influences of sea surface temperatures on costal stations.

d. Allow for some data being strongly influenced by urban heating

There is an important ALC requirement for a station height map rather than a surrogate sea-level map as produced by Field (1983).

2. Data

Daily average temperature data are required from observing stations with a white painted louvred screen with base 1.2 m above grass covered ground. The screen should not be over-shadowed by buildings or trees. The daily average maybe derived from the average of maxima and minimum temperatures or from the average of hourly temperatures when these are available.

The idea of using accumulated temperature over several months allows one value to be used in place of several individual monthly values. For each year of record only one value is available, however, which means that many

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years of record are required to determine a good approximation to the long period average. Preferably thirty years of records should be used but in practice a compromise must be made between less than one hundred stations all with the same thirty years record and several hundred stations with relatively few years of record. The twenty year period 1961 to 1980 was chosen because in England and Wales about one hundred stations had a complete record in this period and a further one hundred stations had almost twenty years of record, see table 1 (a)-(b) for Stations and years of record. Some of the stations in Table 1 (b) had one months record missed and this meant one years record was not available.

In any twenty year temperature record from one station it is possible to have a few extremely high or low values and the average of this sample may be unrepresentative of the longer period average. For this reason, and because the sparcity of data makes even a few unrepresentative stations difficult to assimilate, the median temperature is calculated instead of the average.

The benefit of utilising the hundred and forty extra stations, see Table 1 (b), with fifteen to nineteen years of record is obvious from plotting the data on a map and observing . the benefit to the temperature analyst, see Figure 1. Fig 1 shows the twenty year stations located by a X and the additional stations located by a O. A temperature map analysed using all the stations is shown in Fig 2. The temperature map drawn by Soil Survey using many fewer stations is shown in Fig 3 for comparison. The differences between the two maps is not as dramatic as first appears because of the additional topographic features included in Fig 2. There are differences of one hundred day degrees in many places, however, especially near the coast. Note that in Fig 3 some of the errors are associated with the countrywide regression approach used by Soil Survey, eg the sixteen hundred isotherm passes through a station with a value of 1536. Also some of the differences between the two maps is due to Fig 2 being based on 1961 to 80 whereas Fig 3 is based on 1959 to 78, however, this difference is relatively small.

3. Topography

In general temperature reduces as height above sea level increases and for England and Wales a temperature map looks much like a map of topography. The close relationship between temperature and topographic height can be used to overcome many of the problems due to sparcity of data. If a detailed map of accumulated temperature is required then this may be achieved by using derived regional temperature versus height lapse rates and hand and eye mapping using a topographic map as a background field. This method was used by the author.

Alternatively if computer methods are preferred the station data can be normalised by increasing the January to June accumulated temperature by one degree C for each meter above sea level; this approximates to the correct lapse rate and precision is not important here. The normalised data effectively nullifies the effect of topography and the data can be analysed subjectively or by numerical methods. The accumulative temperature for any location can be obtained by interpolation from the relatively smooth normalised temperature map and subtracting one degree C for each metre above sea level. The problem of producing the final temperature map can be overcome by numerical methods since the topographic field is available in computer compatible, ie digitised, form. This method was envisaged by Field (1983).

4. Sea Surface Temperature

The sea surface temperatures are generally warmer than the screen temperature at inland sites in the winter months and this results in the coastal fringe being warmed in January and February. In the summer months the nighttime minima at these places is not so low as at inland sites but this is counter-balanced to a large extent by the reduction in daytime maxima. These coastal effects are most marked in south west England but other western and southern coasts also show similar characteristics. The shallower and colder North Sea does not have such a warming effect although the prime cause is probably the fact that onshore winds in the east of England in winter imply the air is coming across Scandinavia, the Baltic Sea which is frozen over in winter, or eastern Europe, all typically very cold in January and February.

The warmer south and west coastal fringe provides a challenge to the analyst because he must extrapolate inland and along the coast from the relatively few data points. The geography of the coastal plain and the influence of estuaries is important.

An illustration of the coastal problem is given in Fig 4 which shows the height versus accumulated temperature for those stations shown plotted in Fig 1 and 2 except the coastal stations are not included because a large number of them are around the sixteen hundred day degree C and over and these high values bias any regression analysis. For only the stations shown plotted in Fig 4 the best fit height - temperature relationship is given by:-

1 metre = 1.2 day degree C

When the coastal stations are included the best fit is given by:-

1 metre = 1.6 day degree C

In Cornwall the corresponding figure is:-

1 metre = 1.8 day degree C

Near the coast of south east England the figure is:-

1 metre = 1.0 day degree C

Field (1983) used a single height reduction of 1.0 day degree C per 100 metres.

5. Urban Heating

Some of the temperature recording stations are located in towns and it is noticeable that these are significantly warmer than nearby open country sites. Data from Southampton and Portsmouth, see Fig 2, illustrates the urban warming on the January to June average accumulated temperatures. The warming is a real phenomena and it varies from about 50 day degree C for some of the medium sized towns to 100 day degree C for cities such as London and Manchester.

Conclusions

The author used all the temperature data available for the 20-year period 1961-80 to plot the Median Accumulated Temperature (Jan to June) above base 0 °C and

analysed the data using hand and eye methods together with his judgements concerning topographic height, sea and estuary, and urban heating effects. This is probably the best map which can be produced within reasonable limits of time and expense. To digitise the map for computer use a great deal of effort is required either using computer line following techniques or mannual methods. This contrasts with the Soil Survey modelling approach, ie. relating accumulated temperature to topographic height, Easting and Northing coordinates and using a countrywide average relationship to determine the value of temperature at any location with a specified height above sea level. The latter has attractions for computer use but introduces errors at the mapping stage.

Any comments or suggestions relating to this paper should be addressed to the author.

References

Field M (1983) Agricultural Land Classification - some meteorological aspects of mapping accumulated temperature in the revised scheme. Agricultural Memo. No. 984.

Jones R J A (1984) Private Communication.

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FIGURE 1. LOCATION OF STATIONS WITH 15 YEARS OR MORE TEMPERATURE RECORD (1961-80)

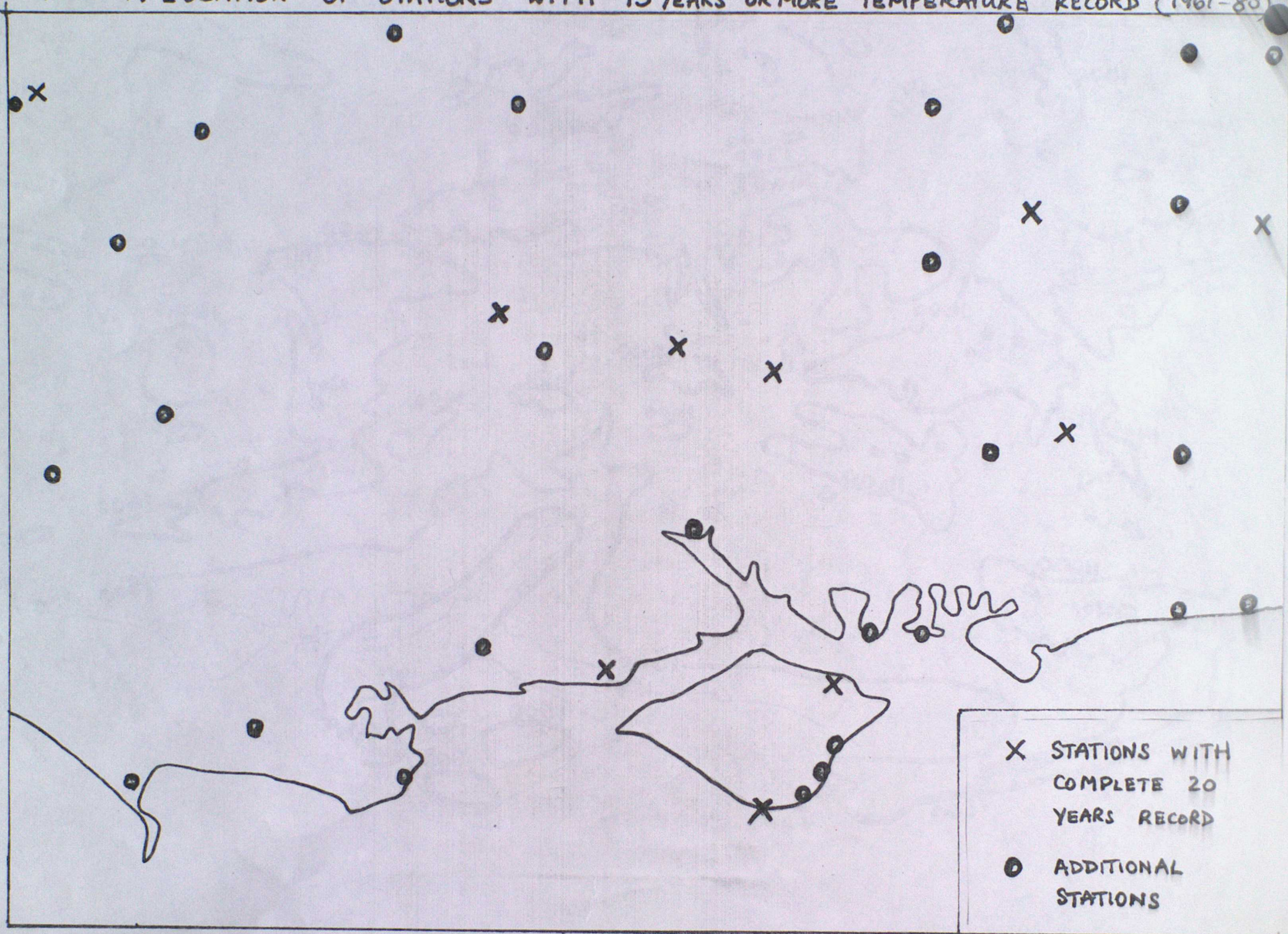


FIGURE 2. ACCUMULATED JAN TO JUNE TEMPERATURE ANALYSED BY J.F. KEERS (MET. O.)

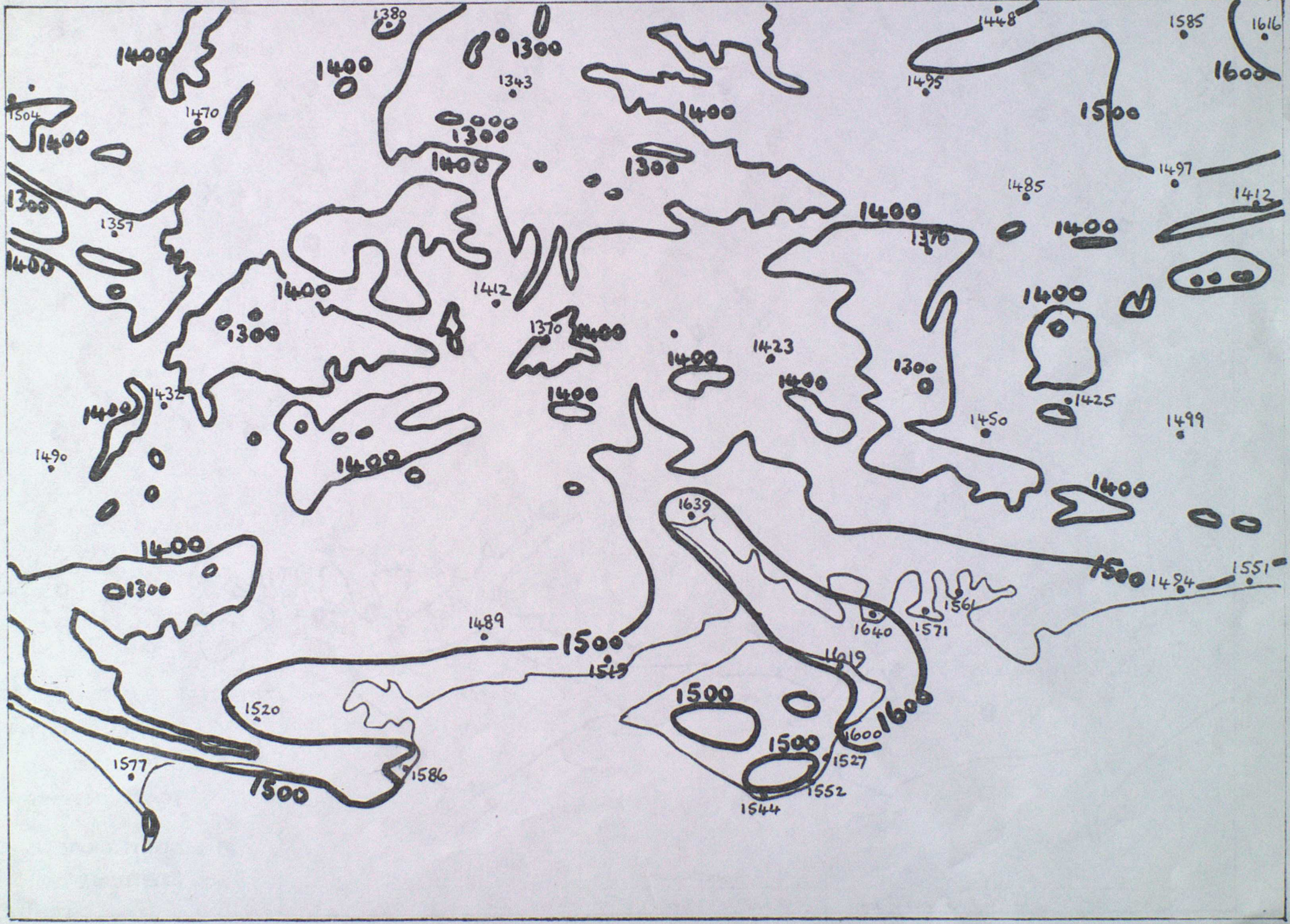
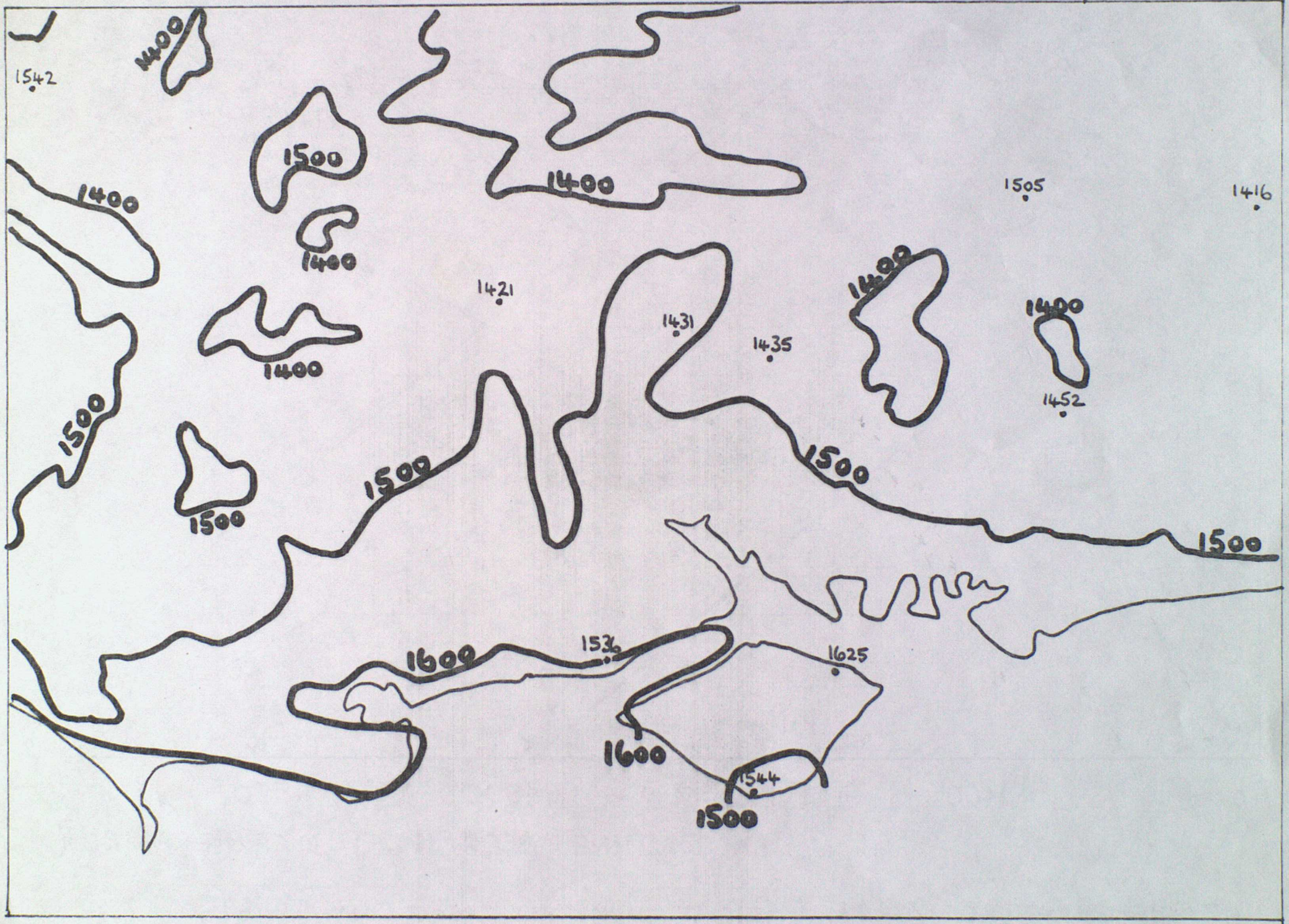


FIGURE 3. ACCUMULATED JAN TO JUNE TEMPERATURE FROM SOIL SURVEY MAP.



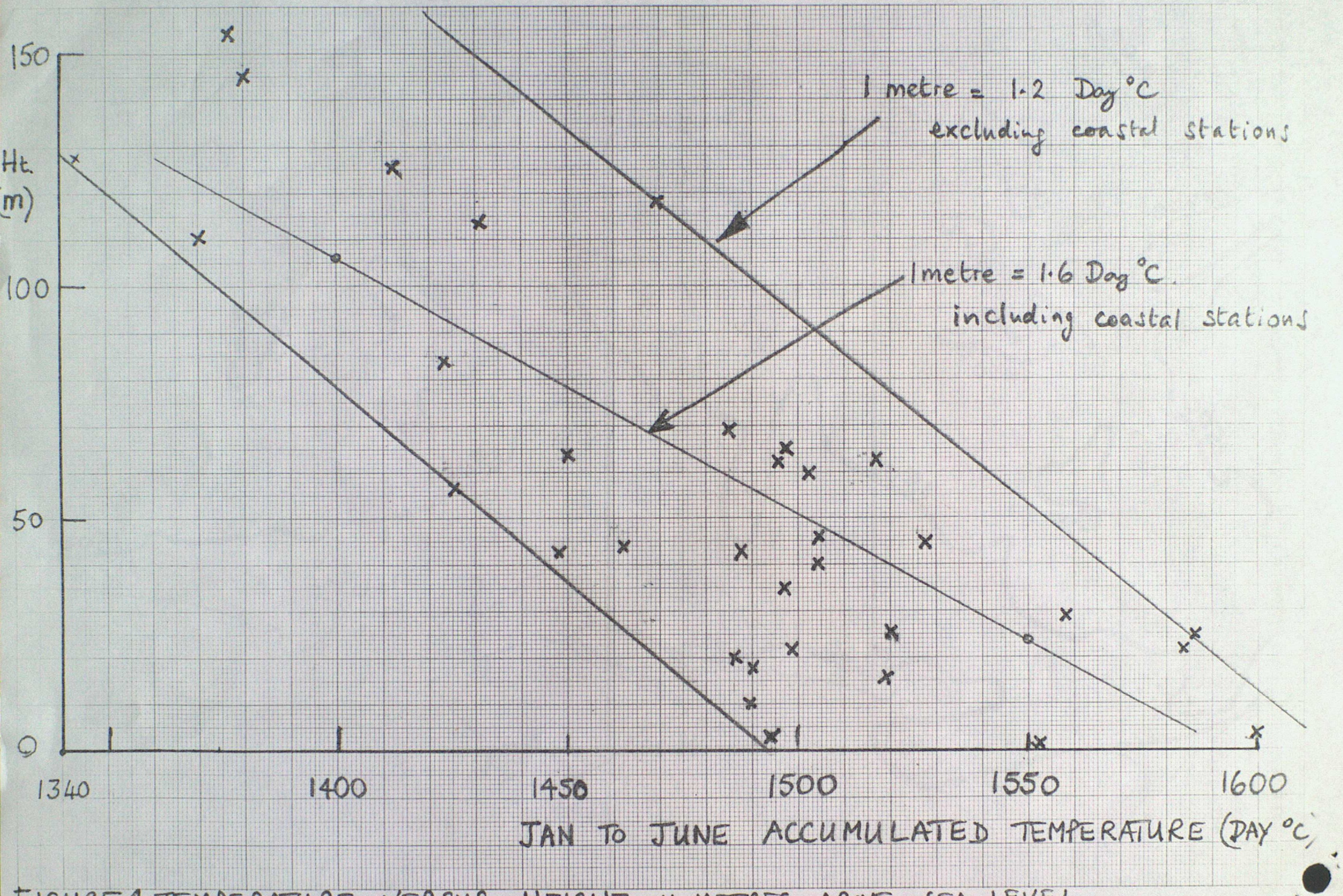


FIGURE 4. TEMPERATURE VERSUS HEIGHT IN METRES ABOVE SEA LEVEL.

TABLE I b STATIONS WITH INCOMPLETE RECORD.

T is JAN – JUNE ACCUMULATED TEMP °C

H is ALTITUDE ABOVE MSL IN METRES.

STATION NAME	GRID REF	T	H (m)	YEARS
Aigburth	3384 3852	1508	12	1968-1980
Alwen	2957 3529	1068	335	1959-1981
Bala	2935 3356	1268	163	1970-1980
Bastreet	2244 765	1325	236	1970-1980
Bath	3751 1638	1470	118	1961-1980
Binbrook	5195 3958	1273	108	1963-1980
Brighton	5313 1040	1563	10	1961-1980
Botwnnog	2263 3313	1439	34	1960-1981
Bowhill	3428 6278	1186	168	1961-1980
Brize Norton	4292 2067	1420	81	1968-1980
Brooms Barn	5753 2657	1402	75	1964-1981
Brynamman	2718 2143	1402	183	1970-1980
Bwlchgwyn	3236 3520	1074	386	1961-1980
Caistor	5082 4019	1391	21	1966-1980
Caldecott	4865 2932	1389	53	1959-1981
Carmarthen	2412 2183	1467	15	1962-1981
Ceinws	2759 3061	1405	61	1962-1975
Cenarth Mill	2978 2778	1161	282	1968-1975
Chawleigh	2727 1123	1365	168	1978-1980
Cilfynydd	3099 1939	1310	194	1975-1980
Cirencester	4005 2013	1360	135	1961-1973
Clacton on Sea	6172 2143	1475	16	1961-1980
Cleethorpes	5314 4080	1401	7	1959-1981
Colwyn Bay	2860 3787	1532	18	1971 1980
Corwen	3048 3398	1268	144	1959-1981
Cromer	6208 3422	1396	54	1959-1981
Culdrose	1676 253	1543	81	1960-1981
Cwmystradllyn	2557 3442	1349	204	1975-1980
Derby	4359 3367	1486	48	1961-1978
Downside Abbey	3655 1508	1357	183	1969-1980
East Berghold	6077 2333	1447	5	1961-1980
East Dereham	5994 3138	1446	53	1966-1976
East Hoathly	5509 1144	1437	38	1964-1980
Edenbridge	5492 1472	1413	45	1974-1980
Esgairwen-Uchaf	2609 2453	1184	332	1970-1976
Eskdalemuir	3235 6026	1072	242	1961-1980
Exeter	3001 933	1553	32	1961-1980
Exton	2962 1338	1251	329	1973-1980
Falmouth	1802 325	1611	51	1931-1981
Grizedale	3337 4942	1225	91	1960-1981
Hadlow College	5628 1497	1448	27	1967-1980
Hampton Loade	3752 2869	1392	70	1970-1980
Harrogate	4303 4579	1287	63	1961-1980
Hartburn Grange	4407 5185	1273	31	1970-1980
Hartland Point	2231 1276	1497	93	1961-1980
Hartlepool	4510 5327	1386	9	1959-1981
Hayling Island	4716 988	1571	4	1959-1981
Hereford	3520 2387	1477	51	1970-1979
Herstmonceaux	5645 1099	1455	18	1977-1980
Huddersfield (Oakes)	4113 4177	1258	232	1961-1972
Kielder Castle	3632 5935	1070	201	1961-1980
Lake Vyrnny	3017 3188	1128	303	1959-1981
Letcombe Regis	4380 1863	1437	107	1960-1981
Lincoln	4962 3719	1375	6	1959-1981

TABLE Ia. STATIONS WITH 20 YEARS (1961-80) TEMPERATURE RECORDS AND THE MEDIAN VALUE OF ACCUMULATED TEMPERATURE JANUARY TO JUNE °C

No	Name	H (m)	TEMP
1	Aberporth	133	1413
2	Askam Bryan	34	1359
3	Aylesbury	96	1411
4	Boscombe Down	126	1412
5	Bradford	134	1309
6	Bramham	54	1308
7	Bude	15	1570
8	Buxton	307	1121
9	Cardington	29	1432
10	Carlisle	26	1344
11	Cambridge (BOT)	12	1488
12	Cambridge (NIAB)	26	1466
13	Cawood	6	1361
14	Cheltenham	65	1505
15	Cockle Park	99	1198
16	Coltishall	17	1393
17	Cranwell	62	1361
18	Crumbland Plant	245	1289
19	Cwmystwyth	301	1158
2o	Dale Fort	33	1579
21	Durham	102	1263
22	Eastbourne	7	1565
23	East Malling	37	1474
24	Elmdon	96	1377
25	Everton	16	1519
26	Faversham	48	1453
27	Fernhurst	57	1425
28	Filton	59	1502
29	Finningley	10	1476
30	Gatwick	59	1424
31	Gloucester	23	1582
32	Gogerddan	31	1467
33	Gorlestone	4	1381
34	Goudhurst	85	1399
35	Hastings	45	1528
36	Hawkridge	314	1197
37	Haydon Bridge	79	1266
38	Heathrow	25	1585
39	Helmshore	260	1179
40	High Mowthorpe	175	1151
41	Hoddesdon	43	1488
42	Hull	2	1446
43	Hurley	43	1448
44	Hurn	10	1489
45	Keele	179	1275
46	Kew	6	1616
47	Kirkham	24	1366
48	leeming	32	1357
49	Loggerheads	210	1218
50	Long Ashton	45	1504
51	Long Sutton	145	1376
52	Lowestoft	25	1388
53	Lyneham	145	1380
54	Lyonshall	155	1369
55	Manston	44	1462
56	Martyr Worthy	84	1423
57	Mountbatten	27	1598
58	Newport	64	1360
59	Newton Rigg	171	1222
60	Oxford	63	1517
61	Pen-Y-Ffridd	84	1477
62	Pershore College	40	1504
63	Porton	111	1370
64	Preston Wynne	84	1365
65	Rhoose	67	1451
66	Ringway	75	1443
67	Rosewarne	76	1583
68	Rothamstead	128	1348
69	Russington	3	1494
70	Santon Downham	24	1367
71	Shawbury	72	1371
72	Shoeburyness	2	1504
73	Silphno Moor	203	1149
74	Silsoe	61	1403
75	Skegness	5	1378
76	Slaidburn	192	1202
77	Stanstead	101	1382
78	Starcross	9	1556
79	Stratford	49	1422
80	Sutton Bonington	48	1400
81	Swansea	10	1600
82	Terrington St Clements	3	1402
83	Trawsgoed	61	1397
84	Valley	10	1528
85	Warsop	46	1338
86	Wattisham	89	1346
87	Wellesbourne	47	1404
88	Wisley	35	1497
89	Wittering	73	1409
90	Woburn	89	1383
91	Writtle	32	1431
92	Wye	56	1441
93	Wyton	40	1462
94	Yeovilton	18	1490

STATION NAME	GRID REF	T	H (m)	YEARS
Lizard	1700 119	1643	73	1964-1980
Llandrindod Wells	3061 2605	1287	235	1961-1973
Llanfair Caereinion	3133 3057	1314	236	1978-1980
Llangenny	3241 2184	1454	122	1974-1980
Llety-Evan-Hen	2693 2851	1229	290	1961-1976
Llwynon	3011 2113	1267	241	1961-1979
Macclesfield	3911 3741	1357	152	1961-1980
Malvern	3790 2461	1511	62	1959-1981
Manchester We Ce	3839 3985	1560	69	1962-1980
Mansfield	4537 3622	1345	114	1959-1981
Marchmont	3743 6484	1169	152	1961-1980
Marleborough	4185 1686	1343	129	1961-1980
Mickleham	5173 1527	1412	55	1961-1980
Milford Haven	1892 2054	1533	37	1965-1980
Moel Cynnedd	2843 2877	1053	358	1969-1980
Moor House	3758 5328	742	556	1959-1980
Morecambe	3431 4645	1477	7	1961-1980
Morley St Botolph	6061 2996	1362	46	1969-1980
Nettlecombe	3057 1377	1435	96	1969-1980
Newquay	1812 614	1648	53	1961-1979
Newtown Linford	4530 3095	1348	119	1959-1981
North Heath	5069 1227	1499	21	1969-1980
Okehampton	2585 928	1178	372	1977-1980
Orielton	1953 1992	1506	61	1965-1980
Oswestry	3279 3295	1327	174	1961-1980
Penkridge	3920 3116	1341	101	1961-1980
Penmaen	2531 1889	1489	87	1968-1980
Penzance	1469 302	1712	19	1960-1981
Pickering	4795 4842	1281	44	1963-1980
Plumpton	5356 1135	1494	76	1966-1980
Pontefract	4453 4211	1367	78	1961-1980
Porthcawl	2822 1771	1597	6	1961-1980
Preston Montford	3432 3144	1405	67	1977-1980
Preston (Moor Park)	3537 4311	1419	33	1961-1980
Raunds	4991 2721	1416	59	1959-1981
Redesdale	3834 5955	1015	238	1971-1980
Rhyl	3001 3807	1504	9	1959-1978
Rodney Stoke	3488 1501	1489	40	1965-1980
Rogate	4809 1237	1450	64	1970-1980
Rugby	4507 2749	1369	116	1959-1981
Ryde	4597 928	1619	4	1959-1981
St Austell	2018 525	1575	94	1959-1976
St Catherines Point	4498 753	1540	16	1964-1981
St Helens	3488 3938	1467	76	1974-1980
St Mawgan	1873 642	1558	103	1961-1980
Sandown	4604 846	1600	4	1959-1981
*Seahouses	4219 6322	1241	11	1964-1979
Sellafield	3027 5032	1398	13	1959-1981
Shanklin	4581 808	1527	55	1959-1981
Sheffield	4339 3873	1425	131	1959-1981

STATION NAME	GRID REF	T	H (m)	YEARS
Sheffield (Dore)	4309 3817	1980	206	1977-1980
*Shinfield	4734 1686	1495	61	1961-1975
Shrewsbury	3517 3136	1439	55	1961-1980
Sidmouth	3124 873	1570	10	1961-1980
Slapton	2824 449	1622	32	1961-1980
Southampton	4416 1112	1639	3	1961-1980
Southport	3371 4207	1374	5	1961-1980
Southsea	4637 991	1640	2	1959-1981
Squires Gate	3316 4316	1420	10	1961-1980
Swanage	4030 794	1586	11	1961-1980
Swyddffynnon	2696 2655	1345	179	1961-1973
Tavistock	2482 748	1488	139	1961-1979
Teignmouth	2941 728	1623	3	1961-1979
Tenby	2129 2001	1501	5	1974-1980
Thorney Island	4761 1023	1561	16	1957-1976
Torbay (Torquay)	2909 638	1673	8	1961-1980
Totnes	2797 629	1558	85	1969-1975
Trawsfynydd	2695 3390	1346	193	1961-1981
Tregaron	2669 2625	1303	178	1975-1980
Usk	3370 2018	1451	21	1961-1980
Ventnor	4556 777	1552	135	1959-1981
Waddington	4988 3653	1363	68	1961-1980
Wallingford	4618 1898	1431	48	1961-1980
Walsall	4058 3010	1367	163	1961-1976
Watnall	4503 3456	1390	117	1957-1981
*West Raynham	5847 3245	1320	73	1961-1980
Weymouth	3661 795	1577	23	1970-1980
Whitchester	3721 6589	1051	255	1963-1980
Whiteford Burrows	2438 1941	1563	5	1969-1980
Wincanton	3704 1286	1432	113	1962-1980
Winfrith	3820 870	1520	26	1962-1981
Wingerworth	4378 3665	1278	116	1969-1980
Worthing	5160 1035	1551	2	1972-1980